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TEMPERATURE DEPENDENCE ON MODULUS OF RUBBER COMPOUNDS USING SYNTHETIC OSCILLATION

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ABSTRACT: Frequency scan are the most commonly used method to study melt behaviour in the DMA and, at the same time, the most neglected experiments for many users. Sampling frequencies is often perfonned with simultaneous temperature scan to speed up data collection. The application of a complex waveform – synthetic oscillation mode, allows very fast collection of data. This article deal with study of tread rubber compound on Diamond DMA using synthetic oscillation mode and temperature scan. Methodics used in this work is not normalized, it is developing methodics on Institute of material and technological research on Faculty of industrial technologies in Puchov.

KEY WORDS: DMA, rubber, synthetic oscillation

1. INTRODUCTION

Frequency effects can be studied in various ways of changing the frequency: scanning or sweeping across a frequency range, applying a selection of frequencies to a sample, applying a complex wave form to the sample and solving its resultant strain wave, or be free resonance techniques. Frequency scan are the most commonly used method to study melt behavior in the DMA and, at the same time, the most neglected experiments for many users.
Sampling frequencies is often performed with simultaneous temperature scan to speed up data collection. The application of a complex waveform – synthetic oscillation mode, allows very fast collection of data. By combining a set of sine waves into one wave, data can be taken for multiple frequencies in less than 30 seconds. Several approaches are used and have been reviewed [1]. In our case were studied tread rubber compounds on Diamond DMA using synthetic oscillation (SO) mode, temperature scan.
In the SO mode, a complex stress sine wave is applied to the sample and this complex stress wave contains five (5) simultaneous frequencies. The resulting complex strain and stress sine waves are deconvoluted using Fourier transform technology and compared to compute the quantitative viscoelastic properties.

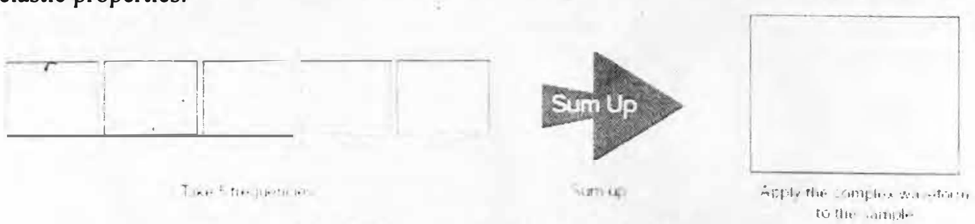

Fig. 1: Synthetic oscillation technique

The advantage of performing frequency multiplexing and Synthetic Oscillation DMA experiments is that much more infonnative sample characterization information can be generated.

2. EXPERIMENTAL PART

Fig. 2: Diamond Dynamic Mechanical Analyzer (DMA)

Fig. 3: Diamond Dynamic Mechanical Analyzer (DMA) with cooling unit

Experiment was performed on Diamond Dynamic Mechanical Analyzer (DMA) using synthetic oscillation technique (1Hz, 2Hz, 4Hz, 10Hz, 20Hz) for three rubber mixtures. For our purpose was choosen only one frequency (10Hz). Presented rubber mixtures are tread rubber mixtures with different content of silica and carbon black fillers. Mixtures are marked A, B, C.

Tab.1: Content of silica, carbon black, SKD and KRALEX in rubber mixtures

	mixture A	mixture B	mixture C
SKD 2	35	25	-
KRALEX	-	-	140
Content of carbon black (%)	6,0	20,5	35,0
Content of silica (%)	30,0	13,5	-

Testing samples were prepared following: from the 2nd stage mixture is pressed out sheet with 2 mm thickness, rubber plate 150 x 150 mm is cut out, samples are pressed out with given curing time and curing temperature and are all conditioned at room conditions for 16 hours before testing. Testing sample is cut out according to asked shape and dimensions, Figure 3.

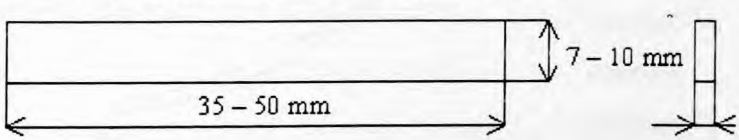

Fig. 3: Sample shape and its required dimensions

Measurements:

- Sample cut out according to Figure 3
- Performing dynamic tensile test according to required results (rising temperature, frequency synthetic oscillation mode (1Hz, 2Hz, 5Hz, 10Hz, 20Hz), constant loading 1N)
- Saving measured data and evaluating results

3. RESULTS AND DISCUSSION

On the text figures are presented measurements of synthetic oscillation mode (10Hz) for all given tread rubber mixtures.

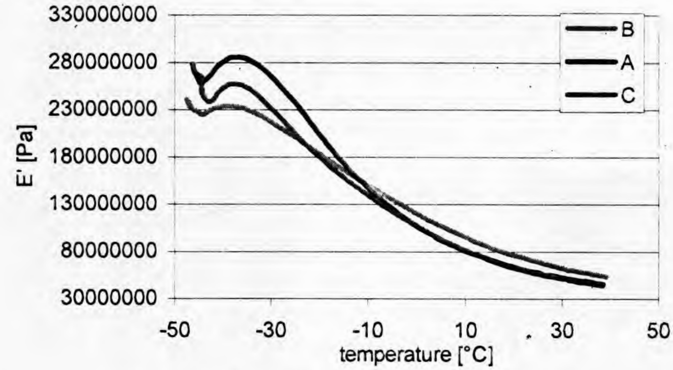

Fig. 4: Dependence of E' vs temperature

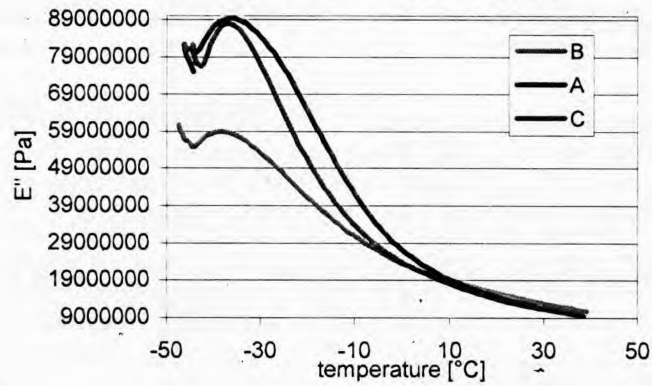

Fig. 5: Dependence of E'' vs temperature

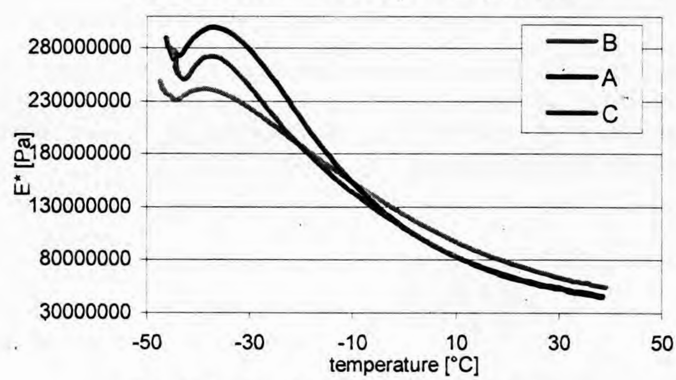

Fig. 6: Dependence of E* vs temperature

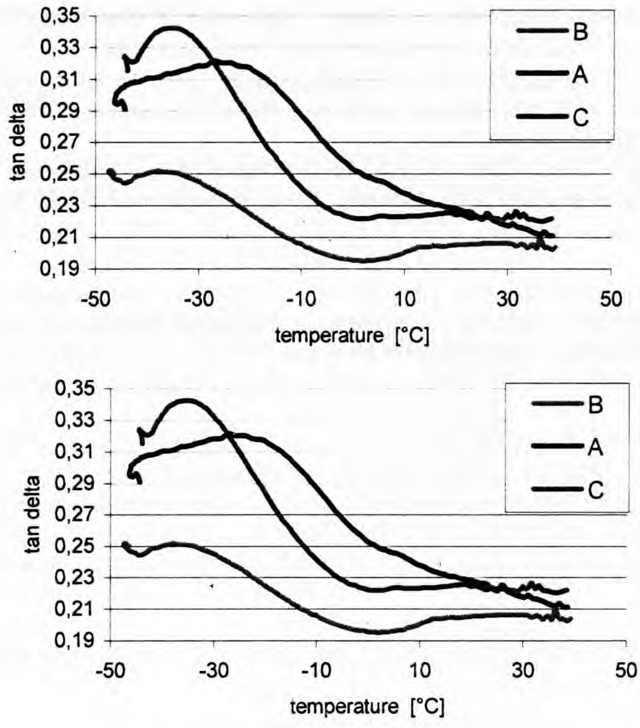

Fig. 7: Dependence of tanδ vs temperature

From presented dependences (Figure 4-6) we can state that mixture A has the highest values of modulus. That can be influenced by its chemical composition (Tab.1). Mixture A contains silica, and it is known that silica influences modulus to higher values, mixture A is stiffer.

From Fig.7 we can see, that tanδ is smaller than in mixture C, which shows that mixture A is harder. According to mixture composition, we can say, that mixture A is oil rubber, contains silica, and that influence vscosity. Mixture B contains also carbon black and silica, that influence dynamic-mechanical properties.

According to Figure 7, where is presented dependence of tanδ vs temperature, we can state for all rubber mixtures, that the highest values reches mixture C, that doesn´t contain silica, but carbon black. In the region of temperatures –30°C – 0°C, the lowest values has mixture B. Mixtures A and C, have better traction properties, and with their composition are more suitbale for winter tyres. In the region of temperatures 0°C – 25°C , mixture A thanks its chemical composition has lower rolling-resistance force, than mixture C and that leads to lower fuel consuption.

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